SUBMICRON X-RAY DIFFRACTION

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At the Advanced Light Source in Berkeley we have instrumented a beam line that is devoted exclusively to x-ray micro diffraction problems. By micro diffraction we mean those classes of problems in Physics and Materials Science that require x-ray beam sizes in the sub-micron range. The beam line has a unity magnification toroidal mirror that produces a 50 by 200 micron focus just inside an x-ray hutch at the position of an x-y slit. The beam path in the hutch consists of source defining slits, a four bounce Ge or Si monochromator, followed by elliptically bent Kirkpatrick- Baez mirror pair which focuses the beam from the slits to sub micron dimensions (0.8 x 0.8 microns). An important feature of this arrangement is the ability to switch between white and monochromatic beams that are essential for characterizing crystals or crystal grains in the sub-micron range. Since sample rotation is fixed we have facilities for precision translation of the specimen to allow us to scan different crystal regions or grains. The sample stage rests on a state of the art six-circle diffractometer equipped with encoders in the main rotation stages calibrated to a second of arc. The detector is a 4K x 4K CCD (Bruker) with a 9x9 cm view area mounted on a detector arm that can be positioned around the sample. The detector itself can also be positioned to better than 1 micron along the detector arm.

Using this facility we have been able to measure the orientation structure of single grains of passivated or buried Al interconnect test structures. Such structures or their equivalents are important in connecting individual components on integrated circuits. Their sub-micron dimensions result in very high current densities that can result in interconnect failures. The variation in sub-grain structure in a single grain is rich in detail. We have obtained detailed maps of misorientations in single grains using white beam Laue diffraction patterns From these we have been able to determine the deviatoric part of the strain tensor. Switching to a monochromatic beam we can measure the strain in a single grain. We find that there are large variations in the strain and orientation from grain to grain and even within an individual grain, reflecting the highly strained and confined geometry of passivated metal lines deposited at high temperature. We can also follow quite easily the energy shift of a single reflection as we heat or cool the sample. With the facility to switch between white or monochromatic x-rays combined with sub-micron focusing it is evident that this technique can be applied to a host of problems in Materials Science & Technology and the Physics of sub micron crystallites.

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